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Mobile applications for weight loss: a guide for use in the primary care setting

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MOBILE APPLICATIONS FOR WEIGHT LOSS: A GUIDE FOR USE IN THE PRIMARY CARE SETTING

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MOBILE APPLICATIONS FOR WEIGHT LOSS: A GUIDE FOR USE IN THE PRIMARY CARE SETTING

MOLLIE E. SEMMER

ABSTRACT

Background

Seven out of every 10 adults in the United States can benefit from weight loss. Overweight and obesity have emerged at the forefront of public health concerns and are associated with significant morbidity and mortality. Primary care providers have the opportunity to identify overweight/obese patients and initiate weight loss efforts with an efficacious treatment plan that addresses individual challenges and barriers. Modest weight loss of 5-10% can be achieved with referral to a high-intensity, on-site, comprehensive lifestyle intervention program. However, most overweight/obese patients do not enroll in these programs; thus, there is a significant demand for alternative weight loss strategies. Providers can help patients individualize and apply the 3 evidence-based components of lifestyle intervention (reduced calorie diet, increased physical activity, and behavior modification) to create a plan that defines weight loss goals, dietary and physical activity targets, and behavior change strategies.

Literature Review

mHealth applications show promise for augmenting weight loss efforts, likely by facilitating behavior change strategies such as self-monitoring. High-quality data is lacking to define the precise role of mHealth apps in weight loss, but a limited number of

studies report significant app features and average frequency of use associated with weight loss.

Proposed Project

Preliminary evidence-based recommendations advise patients to use an mHealth app to log dinner and 1 other meal every day, log all minutes of moderate-to-vigorous physical activity, and log body weight 2-3 times per week. Wearable sensors can be used to enhance user experience, but should not substitute for manually logging physical activity. Patients should monitor their caloric intake, minutes of physical activity, and body weight frequently with reference to their goals and prescribed recommendations.

Conclusion & Significance

Overweight/obesity is a disease that demands attention from the medical profession due to the high prevalence and associated morbidity and mortality. Primary care providers can begin to address the obesity epidemic by propagating patient weight loss efforts. Clinically significant weight loss can be accomplished with lifestyle modification, so providers should be encouraged to prescribe evidence-based lifestyle recommendations for reduced caloric intake, increased physical activity, and behavior change strategies. Patients can actively engage with these recommendations by using an mHealth app with guidance from their providers. Employing pragmatic lifestyle interventions that incorporate evidence-based strategies and encourage longevity may decrease the prevalence of overweight/obesity and its' associated chronic conditions.

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LIST OF ABBREVIATIONS

Apps……...Applications

BMI……....Body mass index

CITY……..Cell Phone Intervention for You

CBT……...…….Cognitive-behavior therapy

CI……..……..Confidence interval

CME……...Continuing medical education

CVD…….…Cardiovascular disease

DPP…….....Diabetes Prevention Program

E-LITE……..Evaluation of Lifestyle Intervention to Treat Elevated Cardiometabolic Risk in Primary Care

Kcal……..Kilocalorie

Kg…….....….Kilogram

mHealth……...…Mobile health

MFP…….MyFitnessPal

NDPP……...……National Diabetes Prevention Program

OR…….....Odds ratio

PCP……Primary care provider

RCT…….....Randomized control trials

SD……...….Standard deviation

SE……Standard error

INTRODUCTION

Background

Nearly 7 out of every 10 adults in the United States would benefit from weight loss. In 2014, an estimated 69.5% of adults were classified as overweight (body mass index, BMI $\geq$ 25.0 kilogram (kg)/m^2) or obese (BMI $\geq$ 30 kg/m^2) and the prevalence of obesity climbed to 36.4%.[1] Overweight and obesity are associated with chronic conditions such as hypertension, dyslipidemia, type 2 diabetes mellitus, cardiovascular disease (CVD), and cancer that predispose patients to significant morbidity. Obesity is also associated with an increased risk of all-cause mortality.[2] The relationship between obesity and chronic disease is of principal importance; most of the leading causes of death and disability in the US are chronic diseases[1] and 86% of health care costs are spent in treating patients with chronic conditions.[3]

Obesity and chronic disease have implications for society as a whole and for individual quality of life. Depressive symptoms and impaired psychological well-being have been associated with weight gain, obesity, and chronic disease. It is thought that depressive disorders precipitate chronic disease, which subsequently exacerbate depressive symptoms.[4] The high prevalence of this disease and the magnitude of its individual implications necessitate increased health care provider involvement in preventing, identifying, and treating overweight/obesity.

Diet, physical activity, and behavioral factors are the principal lifestyle components that influence body weight. Thus, treating obesity with weight loss requires interventions targeting daily caloric intake, amount of physical activity, and maladaptive

behaviors.[2] Intensive lifestyle intervention programs focused on diet and exercise have successfully achieved weight loss, reduced the incidence of type 2 diabetes, and improved the risk factors for cardiovascular disease[5–8] with evidence of long-term benefits.[9] However, the application of these programs is limited by resource intensive methodology and inaccessibility to most patients who would benefit from weight loss.[7,10,11]

To address the known barriers of access and sustainability, weight loss programs have investigated the use of technology in interventions and demonstrated success.[12–14] An estimated 64% of Americans own a smartphone, making mobile health applications (mHealth "apps") an attractive tool for weight loss and healthy behavior adaptation.[15] mHealth apps can serve as an adjunct to weight loss plans by offering patients the ability to collect and log significant amounts of relevant data that can facilitate sustainable lifestyle change through evidence-based strategies. A limited number of studies show promise for the use of mHealth apps in weight loss interventions.[16–19]

Primary care providers (PCPs) play an indispensible role in weight loss. PCPs can address the overweight/obesity epidemic by screening all patients' BMI, identifying individual barriers to weight loss, offering treatment options, and guiding long-term weight loss maintenance. Currently, many patients utilize mHealth apps without health care provider involvement, presenting a missed opportunity for providers to aid in weight loss efforts. The utility of weight loss applications may be optimized by PCP involvement for individualized recommendations, guidance, and feedback for app use. Thus, providers should be informed about how to incorporate mHealth apps into patient weight loss plans.

Statement of the Problem

High-quality, long-term, pragmatic trials investigating the efficacy of mobile applications for weight loss are lacking to inform clinical practice. However, a limited number of studies show promise for the use of mHealth apps in weight loss[17] and outline app use characteristics associated with weight loss.[14,16,18,19] Primary care providers could benefit from a comprehensive, evidence-based guide to help patients integrate mobile applications in lifestyle changes for moderate, sustainable weight loss.

Hypothesis

This continuing medical education (CME) curriculum will educate providers about weight loss in the primary care setting and evidence-based use of mHealth applications as a weight loss tool.

Objectives and specific aims

The objective of this curriculum is to provide primary care providers with an evidence-based approach to weight loss that integrates patient use of mHealth applications.

Specific aims

Primary care providers will..

1. Screen all patients for overweight/obesity and effectively assess patient readiness to make lifestyle changes for weight loss

2. Effectively collaborate with patients to address the 3 components of lifestyle intervention for successful weight loss
3. Provide an evidence-based weight loss plan that, when appropriate, incorporates patient use of mHealth applications

REVIEW OF THE LITERATURE

Overview

Over the past several decades, overweight and obesity have affected an increasingly significant proportion of the United States population. The age-adjusted prevalence of adult overweight/obesity (BMI ≥ 25) increased from 56% to 69.5% between 1994 and 2014. The prevalence of obesity (BMI ≥ 30) increased during this time, and importantly, the prevalence of class 3 obesity also increased from 2.9% to 6.9% of the population.[1] This is important because as BMI and waist circumference increase, the risk of type 2 diabetes, hypertension, CVD, and all-cause mortality increases proportionately.[20] Body weight and current obesity classifications can be found in Table 1.

Table 1. Classification of Overweight and Obesity by BMI[a]

	BMI (kg/m2)	Obesity Class
Underweight	< 18.5	
Normal	18.5 – 24.9	
Overweight	25.0 – 29.9	
Obesity	30.0 – 34.9	I
	35.0 – 39.9	II
Extreme Obesity	≥ 40	III

[a]Adapted from NHLBI. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults. 1998.[21]

In consideration of the high prevalence of overweight/obesity in the US, many public health efforts target primary prevention of this disease by encouraging healthy diet and physical activity. Obesity research seeks to minimize the impact of disease and

comorbidities by studying effective, sustainable weight loss interventions for secondary and tertiary prevention. Current treatment options for obesity include lifestyle intervention, pharmacotherapy, and bariatric surgery. An initial weight loss of 5-10% of body weight is associated with meaningful improvements in clinical outcomes and can often be achieved with high-intensity, comprehensive lifestyle interventions that result in average weight loss up to 8 kg.[2]

For patients who do not meet weight loss goals with lifestyle intervention, treatment with adjunctive pharmacotherapy can be considered for patients with BMI > 30 kg/m^2 (or BMI > 27 kg/m^2 plus 1 obesity-related comorbidity) or referral for bariatric surgery when BMI > 40 kg/m^2 (or BMI > 35 kg/m^2 plus 1 obesity-related comorbidity).[22] However, continuous lifestyle modification of dietary, exercise, and behavioral factors is central to the treatment of all overweight/obese patients.

Obesity is a challenging chronic disease that requires lifelong maintenance and support. Patients face many barriers to weight loss such as lack of access to care and exercise facilities, psychiatric illness, finances, competing life priorities, and time. These barriers can be addressed by PCPs who are uniquely positioned to offer continued support for weight loss and maintenance. Research suggests that a large majority of overweight/obese patients report feeling comfortable discussing weight with their current primary care physician.[23] Additionally, patients who are advised by their PCPs to lose weight are more likely to successfully do so.[24] However, only 20% of obese patients have a documented diagnosis of obesity and only 23% have an obesity management plan.[25] This data highlights a specific opportunity for improvement in the management of

overweight/obesity. Although patients often have multiple complex medical problems, PCPs should address overweight/obesity with every patient because of the associated morbidity and mortality and the availability of effective treatment options. Doing so may help patients overcome their individual barriers and succeed in long-term weight loss. Prioritizing patient weight loss may ameliorate obesity-associated health problems and thus facilitate the medical management of many chronic problems.

Technology is an attractive tool for aiding patients with weight loss efforts given its widespread availability and dissemination in the modern era. In the primary care setting, most technology-assisted interventions (e.g. internet, computers, mobile devices) have helped patients achieve significant weight loss when compared to usual care without technology. The technology utilized in these trials facilitated self-monitoring of diet and physical activity and improved motivation for weight loss. It was concluded that technology was maximally effective with the guidance of health care personnel and was of limited utility as a standalone intervention for weight loss.[24]

Smartphones specifically possess growing capabilities for use as weight loss tools. Smartphones are mobile phones that have functions similar to a personal computer such as browsing the Internet, sending emails, and running programs. These programs (or applications, "apps") are widely available and are designed for diverse purposes such as playing games, organizing tasks, shopping, and connecting to social media. Apps for improving health (mHealth apps) allow consumers to log their weight, food intake, and exercise at their convenience to support healthy behaviors. The apps can also collect daily physical activity data using motion sensors, analyze this data, and graphically display

trends to provide real-time feedback to the user. In clinical studies, mHealth apps show promise for health maintenance in patients with chronic conditions[26] and for weight loss.[17]

mHealth apps can help to address the limitations of resource-intensive weight loss programs. The ubiquity of smartphones and mHealth apps allows for potential dissemination of weight loss strategies to populations lacking access to care. The convenience of mHealth apps eases the burden of time-intensive tasks, such as calorie counting. The various logging and monitoring features available in mHealth apps can enhance all three components of a comprehensive lifestyle intervention: maintaining a moderately reduced calorie diet, increasing physical activity, and adapting behavior change strategies.

Weight loss apps likely work through promoting behavior change, the process of modifying dietary and exercise habits, in order to facilitate weight loss. Rivera et al[27] described 8 broad categories of evidence-based strategies found in weight loss interventions: self-monitoring, goal-setting, healthy eating support, physical activity support, social support, weight and/or health assessment, motivational strategies, and personalized feedback. The authors then quantified the availability of these 8 strategies among 393 commercial weight loss apps. The most commonly encountered strategies were self-monitoring (35.3% of apps), physical activity support (27.5%), weight-assessment (25.4%), and healthy eating support (23.2%).[27] The importance of self-monitoring has been established for weight loss[28] and acknowledged by the National Weight Control Registry as one of the most important predictors of weight loss

maintenance.[29] Overall, however, these commercial apps demonstrated minimal utilization of evidence-based strategies for weight loss, suggesting that the current commercial apps are insufficient as a standalone intervention. Additionally, the authors concluded that a large majority of commercial weight loss apps are limited by lack of healthcare expert input in development and lack of scientific evaluation.[27]

An efficacious approach to using mHealth apps for weight loss remains undefined due to a lack of high quality, long-term, and adequately powered trials. PCPs can thus benefit from a summary of the available literature to guide recommendations for patient use of mobile apps. The remainder of this article will describe recommendations for addressing weight loss in the primary care setting, review the current literature on mHealth applications, and propose an approach to counseling patients about using mobile apps for weight loss.

A suggested approach to patient weight loss in the primary care setting

A primary care based approach to the evaluation and management of overweight/obese patients is described in this section and in Figure 1. This approach is adapted from practice guidelines developed by obesity experts for patient management of excess weight.[22]

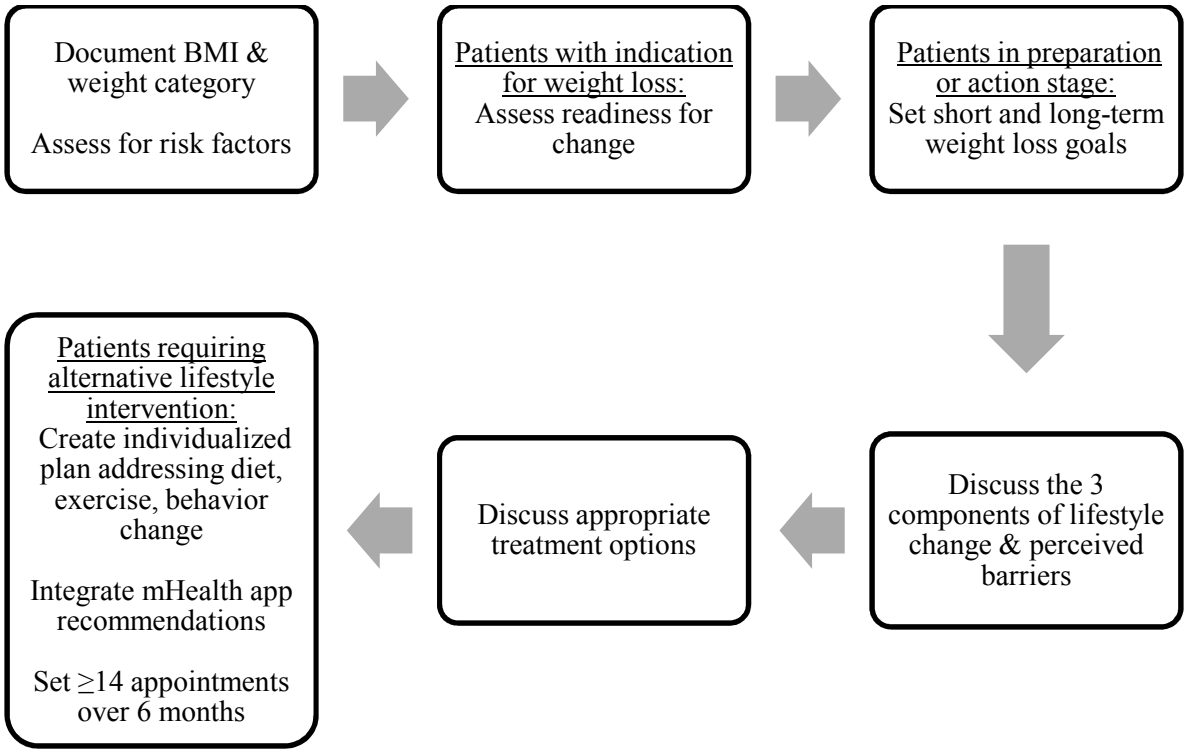

Figure 1: Evaluation of Patient Weight and Management of Overweight/Obesity in the Primary Care Setting

Adapted from Executive Summary: Guidelines (2013) for the Management of Overweight and Obesity in Adults. 2014.[22]

The US Preventive Services Task Force recommends screening all adults for obesity.[30] Upon initial presentation to the primary care office, patients should be weighed with light clothing and no shoes and measured for height. The BMI should be calculated (weight [kg]/height [m]^2) and documented in the patient's medical record. Using BMI classifications, a history and physical examination, clinical assessments (e.g., vital signs, waist circumference), and laboratory values, patient risk should be assessed for CVD and obesity-related comorbidities. Weight loss treatment is indicated for patients with BMI ≥ 30 or BMI 25 – 29.9 with 1 high-risk indicator. Overweight patients without high-risk

indicators should receive counseling for preventing weight gain. All overweight patients with risk factors and all obese patients should be counseled about being at an increased risk for CVD, type 2 diabetes, and mortality.[22]

After determining that a patient has an indication for treatment with weight loss based on BMI and risk factors, it is important to determine whether or not the patient is ready to begin attempts at weight loss.[22] One method of assessing patient readiness for change is the Stages of Change construct from The Transtheoretical Model. The model states that behavior change progresses over time through 6 identifiable stages, sometimes in a non-linear fashion. The PCP goal is to promote patient movement through the stages. Patients in the precontemplation and contemplation stages are not ready for weight loss interventions that require immediate action, but these patients should instead be asked open-ended questions that encourage self-reflection. Patients in the preparation stage, however, have typically committed to taking action and should be engaged in further conversation regarding changes to diet, physical activity, and behaviors. The preparation stage is distinguished from the action stage where patients are currently carrying out a plan on a regular basis with clear strategy and goals. The behaviors from the action stage are incorporated into a new lifestyle during the maintenance stage. Unfortunately, many weight loss patients will experience relapse (i.e. regain weight, discontinue weight loss efforts) and in this situation it can be helpful to reframe the stage as a period to reset and plan for the next action step.[31] It is important for providers to identify which stage the patient is currently in to maximize effectiveness and productivity of patient-provider interactions. Patients in the precontemplation and contemplation stages are unlikely to

respond to weight loss counseling, but may benefit from discussion surrounding their current barriers to change. Patients identified as being in the preparation stage, however, are willing to have productive conversations about lifestyle changes required for weight loss so counseling efforts are most likely be productive.[31,32]

Table 2. Transtheoretical Model Stages of Change[a]

Stages of Change	Description
Precontemplation	No intention to take action within the next 6 months
Contemplation	Intends to take action within the next 6 months
Preparation	Intends to take action within the next 30 days and has taken some behavioral steps in this direction
Action	Changed overt behavior for less than 6 months
Maintenance	Changed overt behavior for more than 6 months
Relapse	Consistent return to problem behaviors and attitudes after a period of successful change

[a]Adapted from O'Connell. Behavior Change. 2014.[31]

Appropriate patients should then be asked about weight loss goals. It may be encouraging to explain that weight loss of only 3-5% body weight can lead to improvements in health, with larger weight loss resulting in greater benefits. Experts recommend setting an initial goal of 5%-10% weight loss within 6 months.[2] PCPs play an important role to clarify expectations for weight loss to ensure patients are not disappointed by modest weight loss. Weight loss goals should be broken up into weekly or bi-weekly increments for short-term goal setting. Establishing realistic and measurable goals is a productive weight loss strategy because it provides an opportunity for patients to feel a sense of accomplishment.[33]

All patients attempting weight loss, regardless of treatment modality, should be engaged in discussion about the three components of lifestyle change: reduced caloric intake, increased physical activity, and behavior modification. These three components

interact to influence weight, so creating an energy deficit through caloric restriction, physical activity, or both results in weight loss. The provider should communicate goals for each component and encourage the patient to contribute his or her ideas and express the perceived barriers.[2]

Table 3. Components of Lifestyle Intervention for Weight Loss[a]

Component	Description
Reduced-calorie diet	Reducing dietary energy intake by prescribing an individualized daily target intake or an evidence-based diet
Increased physical activity	≥ 150 minutes of aerobic activity per week
Behavior therapy	Developing skills to adapt behaviors necessary for weight loss (i.e. self-monitoring, goal-setting)

[a]Adapted from Executive Summary: Guidelines (2013) for the Management of Overweight and Obesity in Adults. 2014.[22]

Reducing dietary energy intake can be accomplished by specifying a daily intake target; typical values, adjusted for body weight, are 1,200 – 1,500 kilocalorie (kcal)/day for women and 1,500 – 1,800 kcal/day for men. Another, more tailored approach uses an equation to calculate individualized daily energy requirements (e.g. Harris Benedict Equation, Mifflin-St Jeor Equation, WHO formula) and prescribes an energy deficit. Both of these approaches require patients to monitor intake. Instead of prescribing a specific caloric target, reduced dietary intake can be accomplished by prescribing select evidence-based dietary approaches[2] that avoid specific foods and subsequently reduce dietary intake. None of the aforementioned approaches have demonstrated superiority; when energy deficits were achieved, all 3 of these approaches have demonstrated successful weight loss in a multidisciplinary setting. This wide variety of efficacious dietary strategies allows for flexibility and individualization of a dietary plan that best suits the

patient based on preference, ability, sustainability, and comorbidities. It is important to highlight that, in addition to a prescribed dietary plan, patients require tools to implement these changes.[2] mHealth apps have several features to facilitate this process and recommendations for use will be described in the following section.

Increased physical activity for initial weight loss is typically prescribed as ≥ 150 minutes of aerobic activity (e.g. brisk walking) per week, preferably in increments of 30 minutes or more (5-7 days/week). Exercise programs that also include resistance training, balance, and flexibility in addition to aerobic activity are preferred. Duration of exercise should be increased gradually over time to prevent injury.[34] For long-term weight loss, higher levels of physical activity (≥ 225 minutes/week) are usually required.[22]

Interventions utilizing behavior therapy with diet and exercise have been shown to result in greater weight loss than diet and exercise alone.[35] The goal of behavior therapy is to restructure learned behaviors surrounding a poor diet and sedentary lifestyle, and shift focus to developing skills that support the behaviors required for weight loss. Several strategies to accomplish this have been described and implemented in weight loss programs, with self-monitoring (of diet, weight, physical activity) being the most common[2] given its significant association with weight loss[28] and long-term weight loss maintenance.[29] Other behavioral strategies include goal setting, stimulus control, changing the environment, problem solving, and relapse prevention planning.[33] Formal programs typically teach these strategies during group sessions, but PCPs can similarly deliver these techniques during office visits. In addition to behaviors, addressing the cognitive components of weight loss (associated thoughts, emotions, and beliefs) is

important for addressing psychosocial issues that may be contributing to obesity and impeding weight loss. Of note, cognitive-behavioral therapy (CBT) for weight loss is available and may be appropriate for some patients.[33]

After having an individualized discussion covering the 3 components of lifestyle change for weight loss, PCPs should discuss the available treatment options for weight loss. The initial treatment for weight loss in all patients is lifestyle modification. Multidisciplinary teams of medical, nutrition, and behavioral experts (trained interventionists) have been proven to be most successful in achieving weight loss; thus, patients should be referred to high-intensity (≥ 14 sessions over 6 months), in-person, comprehensive lifestyle intervention programs if they are available and the patient is interested. Over 50% of patients in these programs are expected to achieve ≥ 5% weight loss (average 5-8 kg). Patients who have never participated in a lifestyle intervention program should be encouraged to do so before starting alternative therapies. If the patient has been previously unsuccessful with comprehensive lifestyle intervention or has other indications for pharmacotherapy or bariatric surgery, the patient should be treated accordingly.[22]

Although high-intensity, in-person programs have been shown to be the most efficacious lifestyle interventions thus far, these programs have limitations and are not accessible to all patients for a wide variety of reasons. Thus, providers should be knowledgeable about available alternative methods for lifestyle intervention delivery.[22] One option is for PCPs to work with their patients to devise an efficacious lifestyle intervention plan that utilizes the same evidence-based principles for weight loss

(reduced calorie diet, increased physical activity, and behavior change). The plan should include long-term (e.g. 6 month) and short-term (weekly or monthly) weight loss goals, a prescribed dietary intervention strategy (e.g. calorie target), a prescribed physical activity goal, and specific behavior components to address. Patient use of mHealth apps should be encouraged and integrated with provider recommendations.

It is important to note that studies have shown that low- to moderate- intensity primary care based lifestyle interventions (< 2 encounters/month) did not result in clinically significant weight loss after 1 year. On-site, comprehensive lifestyle intervention programs (delivered by trained interventionists) have demonstrated that greater weight loss results with increased frequency of contact; moderate-intensity programs (6-13 sessions over 6 months) typically result in lower weight loss than high-intensity programs, with an average of 1 to 3.5 kg over 6 to 12 months. Thus, scheduling at least 14 visits over 6 months is recommended. Alternating provider visits (doctor, physician assistant, nurse practitioner) and nurse visits for weigh-in, discussion, and feedback may be an effective strategy for maintaining regular biweekly visits. Other efficacious weight loss strategies include commercial programs and interventions delivered electronically or by telephone. Although weight loss achieved from these interventions is generally lower than from in-person, high intensity programs, they can be prescribed for appropriate patients if they have been evaluated for safety and efficacy through peer-review.[2]

If patients are successful in initial weight loss efforts, it is important to encourage continued health care provider contact. Patients typically follow a trajectory of maximum

weight loss at 6 months, followed by a plateau, then gradual weight regain. However, the amount of weight regain has been shown to be lower in patients who enroll in a weight loss maintenance program. Thus, it is recommended to refer patients to a long-term weight loss maintenance program that provides at least monthly contact for over 1 year.[22] Alternatively, monthly PCP follow-up for discussion of behavioral factors, maintenance of a reduced-calorie diet, and increased physical activity would likely be beneficial to maintaining weight loss. The ideal length of follow-up time is yet to be determined and should be considered on an individual basis.

Existing research

Lifestyle interventions for weight loss

The 3 components of lifestyle intervention required for weight loss were elucidated through landmark studies that highlighted the importance of lifestyle change and the benefits of weight loss. One such program, the Diabetes Prevention Program (DPP), demonstrated a 58% reduction in the incidence of type 2 diabetes through modest weight loss with improvements in diet and exercise.[7] CVD risk factor status was also improved as evidenced by significant changes in blood pressure, triglycerides, and cholesterol profile. These improvements remained evident at 3 years by decreased use of pharmacologic therapy for hypertension and hyperlipidemia when compared to other study participants.[8]

Patients in the intensive lifestyle intervention were encouraged to achieve at least 7% body weight loss through a low-calorie, low-fat diet and 150 minutes of moderate intensity physical activity per week. Participants were individually educated on diet, exercise, and behavior modifications during 16 customized lessons conducted over 24 weeks.[7] This study is one of many that has informed the current recommendations for efficacious lifestyle intervention for weight loss.[22] However, these intensive, in-person programs require significant time and resources, which limits the reach and maintenance of the intervention.

These limitations have been addressed in translational studies such as the Evaluation of Lifestyle Interventions to Treat Elevated Cardiometabolic Risk in Primary Care (E-LITE) trial. This study successfully adapted the DPP lifestyle intervention for the primary care setting and for remote delivery. Overweight/obese adults were randomized to a coach-led small group, a self-directed DVD, or usual care for 3 months. After this intensive intervention, both intervention groups completed a remote maintenance phase for 12 months via email and online self-monitoring for weight and physical activity goals. Both the coach-led and self-directed groups resulted in significant decrease in BMI compared to usual care after 15 months (mean change in BMI ± standard error [SE] -2.2 ± 0.3, -1.6 ± 0.3, and -0.9 ± 0.3, respectively). The coach-led intervention resulted in significantly greater BMI change than the self-directed intervention (P = .03); however, percent weight loss in the self-directed intervention was still clinically significant at 5% (coach-led: 6.6%). Additionally, both interventions resulted in improved waist circumference and fasting plasma glucose level.[12] This study adapted the diet, exercise,

and behavior principles from the DPP for the primary care setting and modeled the success of small group and remote, self-directed interventions that are supplemented with technology. This study demonstrated that evidence-based strategies for moderate weight loss can be successfully delivered through alternate platforms, thereby increasing the accessibility of these programs.

mHealth apps and weight loss

Recent studies have examined patient use of modern technology by studying smartphones and mHealth apps for improving various health outcomes. mHealth apps have demonstrated success in improving chronic conditions such as the self-management of type 2 diabetes[26] and hypertension.[36] Early trials show promise for the use of mHealth apps as a tool for achieving weight loss in lifestyle interventions.[16–19] More large, high-quality, randomized controlled trials are needed to define the exact role of mHealth apps in weight loss; however, current guidelines can be enhanced to include the use of commercially available mHealth apps to facilitate weight loss. The remainder of this article summarizes current literature on the topic and formulates an evidence-based guide for PCPs to help overweight/obese patients use mHealth apps to achieve sustainable, moderate, long-term weight loss.

The use of mobile apps in weight loss interventions is associated with small but significant changes in body weight and BMI in overweight/obese patients when compared to non-app controls, as described in a systematic review and meta-analysis by

Mateo et al.[17] This meta-analysis of 9 trials, mostly randomized control trials, of about 1,000 participants concluded body weight reduction of 1.04 kg (95% CI -1.75 to -0.34; I^2 = 41%) and BMI reduction of 0.43 kg/m^2 (95% CI -0.74 to -0.13; I^2 = 50%) in study duration from 6 weeks to 9 months. Of note, the weight loss outcomes in this analysis may be understated compared to the current standard of care because many of the control groups were other weight loss interventions (i.e. intensive counseling, self-monitoring techniques, handouts).[17] Although weight loss of 1 kg is not likely to be clinically significant, these results suggest that mobile apps have a significant, positive impact on weight loss and are likely to be effective treatment adjuncts.

A recently published retrospective cohort study examined weight loss among 35,921 users of a popular commercial weight loss app, Noom Coach (Noom Inc., New York, NY, USA). Users were instructed by the application to set a target body weight and record daily food intake and body weight. Physical activity was recorded as steps using smartphone motion sensing. The app generated reports of weight trends, nutrition and calorie summaries, and provided feedback with the goal of helping the user achieve target body weight. Users who logged in and recorded data at least 2 times per month for 6 consecutive months were included in the study; the top 1% of weight variances and participants who entered the default age of 42 were excluded. Of these users, 77.9% reported a decrease in body weight while using the app and 22.7% of app users experienced > 10% weight reduction. The results of this study are limited by being retrospective, lacking a control group, and analyzing user-entered data. However, the results are pragmatic given the availability of the app and are generalizable given the

large sample size.[18] The results from this study support patient use of mobile apps for achieving weight loss. Of note, the National Diabetes Prevention Program (NDPP) has studied a mobile weight loss intervention using the Noom platform.[19]

The relationship between weight loss and mobile apps was studied by Svetkey et al[16] who conducted low-intensity weight loss interventions and randomized 365 overweight/obese young adults to a purely smartphone-delivered intervention, personal coaching intervention enhanced with smartphone self-monitoring, or control group, in the CITY (Cell Phone Intervention for You) trial. Neither the mobile app alone nor personal coaching with app supplementation resulted in statistically significant long-term weight loss after 2 years (-0.99 and -2.45 kg, respectively). The personal coaching group supplemented with smartphone monitoring did result in moderate but significant short-term weight loss (-3.07 kg) relative to control at 6 months (net effect -1.92 kg [CI -3.17 to -0.67], P = 0.003) and relative to the app-delivered intervention at 6 months (net effect -2.19 kg [CI -3.42 to -0.97], P < 0.001) and 12 months (net effect -2.10 kg [CI -3.94 to -0.27], P < 0.025). Weight loss of 5% or more at 24 months was seen only in a small portion of participants, 27.5% of personal coaching, 25.5% of smartphone intervention, and 22.0% of control participants with non-significant differences. The results of this study should be interpreted with the knowledge that the control group did not perform as expected as they actually lost weight instead of gaining weight as reported in similar studies.[16] One possible explanation for the lack of significant long-term weight loss is the low intensity of this intervention with only 6 in-person group sessions. To sustain weight loss beyond 12 months, the number of in-person group sessions should be increased to

current recommendations of a minimum 14 sessions over 6 months.[2] This data supports intervention enhancement with smartphone apps for short-term, moderate weight loss; perhaps the amount and duration of weight loss can be augmented by increasing the number of in-person sessions.

The results from this three-arm design address a question important to both providers and consumers alike, do mobile apps help people lose weight? This study cautions that the study smartphone app was not sufficient for intervention delivery. Participants who had their intervention delivered exclusively through a smartphone app did not have significant weight loss at 6, 12, or 24 months (-0.087, -1.48, -0.99 kg, respectively). The proprietary, study-designed app included goal setting, games, social support, self-management prompts, and self-monitoring (weight, diet, physical activity), features that are frequently offered in commercial apps. The personal coaching group, in contrast, held 6 weekly in-person group sessions led by a dietician to address goal setting, challenges, and social support. In the coaching intervention, participants used the app solely for self-monitoring. The self-monitoring data (weight, diet, physical activity) was incorporated into the coaching sessions and intervention elements were tailored accordingly. Of note, this intervention feature follows the current recommendation for personalized feedback in intervention programs. After completion of the group sessions, participants in the personal coaching group were contacted by phone monthly. The personal coaching group had significantly greater weight loss than the app-delivered intervention at 6 and 12 months,[16] suggesting that partnership with a health care provider for guidance and personalized feedback is indispensable and mHealth apps alone are

unlikely to produce significant weight loss. This is in agreement with previous studies that have concluded that technology is not an adequate substitute for high-frequency in-person contact with the health care system for achieving weight loss.[11,24]

Results from Laing et al[37] also demonstrated non-significant weight loss with patient use of a commercially available app, MyFitnessPal (MFP), as a standalone intervention. MFP incorporates goal-setting, self-monitoring (diet, exercise, and weight) and social support. Overweight and obese patients interested in losing weight (N = 212) were randomized to usual care or app intervention. Patients randomized to the app intervention were briefly introduced MFP by a research assistant in the primary care setting and an instruction video. Both groups were evaluated for weight loss, self-reported changes in behaviors (exercise, diet, self-efficacy), and systolic blood pressure at 3 and 6 months. The use of MFP did not result in increased weight loss compared to usual primary care at 3 months (-0.03 and 0.24 kg, respectively [between-group difference -0.27 kg, P = 0.53]) or 6 months, (-0.03 and .27 kg [between-group difference -0.30 kg, P = .63]) and did not result in improved blood pressure. Notably, patients were not formally assessed for motivation or readiness to change, but were included in the study if they expressed interest in losing weight. Thus, patients enrolled in this study may not have been adequately prepared to make the lifestyle changes required for successful weight loss. In addition, the primary care clinician was not involved in the app recommendation of the app or with follow-up weight loss progress.[37] These results support the conclusion that current commercially available mHealth apps alone, without

provider involvement for assessment, counseling, and feedback are not effective interventions for weight loss.

Recommendations for patient use of mHealth apps

Encourage any patient that is interested and possesses a smartphone (or similar technology, e.g. tablet) to use a mobile application to facilitate weight loss efforts. Patient comfort with technology can be gauged by asking if he or she owns a smartphone and if so, what he or she uses it for. Only a small number of populations have been studied thus far to determine the efficacy of mobile apps for weight loss. The reported characteristics of participants enrolled in studies that have successfully achieved weight loss with mobile app use are participants around 30-40 years of age, college educated, and with a BMI of 30-35.[16–19] A majority (70-80%) of participants in these studies are female, but men have actually been shown to have greater weight reduction than females in one retrospective cohort analysis.[18] The current lack of high-quality data precludes the ability to define patient populations that would be most likely to succeed with this approach; thus, the decision of whether or not to recommend a mobile app to a patient for weight loss should be based on the patient's willingness to try the app and not on patient characteristics.

Most mobile applications that promote weight loss boast numerous features, from scanning barcodes to reminding users to log their lunch. Health care providers are left to answer the questions, which app should I download? How should I use it? The mobile application landscape is changing on a daily basis with the addition of new applications,

updates to existing platforms, and evolution of smartphone capabilities. It is helpful to simplify the utility of current commercial mobile apps by conceptualizing them as a tool for improving self-monitoring, an important strategy that has been associated with long-term weight loss.[29] Apps that allow for self-monitoring of diet, weight, and exercise are appropriate for use. Encourage patients to browse apps and experiment to find an app that they enjoy using, with the goal of increasing adherence rather than choosing the best app. Apps can ease the burden of self-monitoring by providing a user-friendly platform that simplifies food and weight logging. Large, searchable food databases that include the caloric and nutrition content of a large variety of grocery and restaurant items eliminate the need for manual calorie counts calculations. Weight loss strategies commonly encountered in mHealth apps are listed in Table 4.

Table 4. Weight Loss Strategies Featured in mHealth Weight Loss Apps[a]

Strategy	App feature	Examples
Self-monitoring: weight[b]	Enter and store daily weight data	Displays graphic weight trend and goal weight
Self-monitoring: diet[b]	Enter and store daily food and caloric intake	Searchable food database or barcode scanner, displays daily calorie totals
Self-monitoring: physical activity[b]	Enter and store minutes of physical activity	Searchable exercise database, displays weekly goal
Social support	Social media, communicate with other users	Forums, blogs, groups, community profile, add friends
Goal-setting	Set weight loss, caloric intake, physical activity goals	Enter goal weight for a certain date
Healthy eating support	Nutrition education and information, skills development	Nutrient composition of logged foods, healthy eating guidelines, meal plans, saves frequently used recipes
Physical activity support	Exercise education and	Fitness plans, exercise

	information, skills development	guides, tracking of daily physical activity (i.e. steps)
Weight and/or health assessment	Assessment of BMI or weight-loss goal	Provides weight category (overweight/obese), identifies unhealthy weight loss goals
Motivational strategies	Prompts, rewards, gamified design	Progress reports, reminders, challenges

[a]Adapted from Rivera et al.[27]
[b]Essential strategy and app feature for weight loss

Studies are beginning to outline the characteristics of patient app use that are important for weight loss. Results from these studies can be used to advise patients about what type of information to log in the app and how often. Chin et al[18] examined data from users of the Noom Coach app and analyzed several variables related to diet, exercise, and weight to determine how often these variables were logged and subsequently related to weight change. Dinner, weight, and exercise input frequencies were positively and significantly correlated with weight loss and maintenance (regression coefficient (β) = 2.56, 95% CI = 2.27–2.85, P < 0.001; β = 2.01, 95% CI =1.85–2.17, P <0.001; β = 0.72, 95% CI =0.59–0.58, P <0.001, respectively). The input frequency for dinner was the most important factor among all variables for successful weight loss (odds ratio, OR = 10.69, 95% CI = 6.20 – 19.53, P < .001). Interestingly, logged calorie intake did not have a significant relationship to weight loss, which may be attributable to errors in logging or database inaccuracies.[18] Data from this analysis suggests that the most important component of app use for weight loss is self-monitoring of meals (specifically dinner), weight, and exercise.

The National Diabetes Prevention Program (NDPP) recently studied a 24-week mobile weight loss intervention delivered through a Noom structured curriculum with the

support of a virtual coach for 43 overweight/obese patients with prediabetes. Participants who completed the program (N = 36) lost 7.50% of baseline body weight (mean ± SD - 7.01 ± 4.83 kg) at 6 months and showed high levels of engagement in the app.[19] Consistent with findings from Chin et al,[18] the primary app engagement characteristics that significantly predicted weight loss were the number of weekly weigh-ins and number of meals logged. Meals were logged on average 13.93 ± 6.00 times per week and participants weighed in 1.04 ± 0.93 times per week. The percent weight loss achieved increased for every standard deviation increase in meals or weigh-ins logged. These variables explained 43% of the weight loss variance in this study. Further analysis indicates that group behavior, such as posting in an online forum, positively influenced meal logging which in turn promoted weight loss.[19] This finding indicates that social support is also an indirect promoter of weight loss, as it appears to enhance self-monitoring.

Frequent self-weighing is a self-monitoring parameter that has been well described in weight loss literature, with current recommendations advising at least weekly self-weigh-ins.[22] In the CITY trial, participants in the personal coaching group who experienced moderate weight loss of 3.07 and 3.58 kg at 6 and 12 months respectively, self-weighed on their mobile app on average 2.2 ± 1.6 times per week for the first 6 months and an average of 1.3 ± 1.4 times per week for months 7 through 12. Aside from weigh-ins, the personal coaching group participants interacted with the app (tracking dietary intake and physical activity) an average of 1.8 ± 1.5 times per day for the first 6 months and 0.8 ± 1.1 times per day for months 7 through 12.[16] This amount of

weekly interaction is, on average, slightly less than the frequency of meal logging seen in the mobile NDPP intervention, which resulted in a greater amount of weight loss.[19] Interestingly, the CITY trial participants in the app-delivered intervention group, who did not demonstrate significant weight loss, self-weighed more times per month at 6 months (4.0 ± 1.7) and 12 months (3.3 ± 1.9).[16]

These results highlight the mobile app's role as a self-monitoring tool and outline a framework for counseling patients about how to most effectively use a mobile app for weight loss. Patients should be counseled that the major purpose of the app is to log their meals, weight, and exercise. Dinner and weight logging should take priority over other features of the app.

Recommendations for diet and weight tracking in mHealth apps for weight loss that incorporate the above findings are as follows:

- Log dinner and at least 1 other meal every day (food and drink, 7 days per week) in an app. Monitor daily caloric intake to meet prescribed goal and adjust caloric intake accordingly
- Self-weigh and log weight 2-3 days per week in an app. Monitor weekly progress toward prescribed short-term and long-term goals

Exercise is a well-established component of weight loss and current recommendations advise at least 150 minutes per week of moderate-to-vigorous physical activity (e.g. brisk walking) for weight loss and 200-300 minutes per week for weight maintenance.[34] Tracking minutes of physical activity in mHealth apps is simple, convenient, and featured in many weight loss apps and smartphone operating systems.

Current literature suggests that exercise logging plays a smaller, but significant role in weight loss relative to diet and weight logging.[18] Patients should be encouraged to track their minutes of moderate-to-vigorous physical activity on mobile apps with the goal of meeting the recommended amount of weekly exercise for weight loss or maintenance.

Many companies have marketed smartphone compatible devices that use additional sensors to monitor physical activity, heart rate, and sleep. The devices provide the user with real-time information about daily steps, caloric expenditure, and minutes of physical activity. Jakicic et al[14] recently published the Innovative Approaches to Diet, Exercise, and Activity (IDEA) trial that examined the use of wearable sensors for weight loss. In this randomized trial of 470 overweight/obese young adults in a weight loss intervention, weight loss was compared over 24 months between a group that monitored diet and physical activity using a website alone (standard intervention) and a group that utilized a wearable device with a web-based platform (enhanced intervention). The goal of the enhanced intervention was to improve long-term weight loss; however, the group that used the wearable device lost significantly less weight than the standard web-based self-monitoring intervention at 24 months (2.4 kg, 95% CI, 1.0-3.7, P=.002). The standard intervention group lost 5.9 kg (95% CI, 5.0 - 6.8) and the enhanced group with the wearable device lost 3.5 kg (95% CI, 2.6 - 4.5) at 24 months.

In this study, both groups underwent the same initial 6-month intervention that met weekly, in-person, for group sessions focusing on behavioral topics related to weight loss, diet, and physical activity. Participants were provided meal plans and were prescribed reduced calorie intake of 1200-1800 kcal/day (based on initial body weight)

and moderate-intensity exercise 5 days/week. The authors previously demonstrated that accumulating bouts of 10-minute exercise throughout the day results in improved initial adoption of exercise in overweight patients, so this option was provided. For the first 6 months, all participants self-monitored with a weekly paper diary that was reviewed at the in-person visits by interventionists who provided written feedback. For both groups, this was followed by 18 months of monthly group sessions and individualized telephone contact, weekly text messages, and instructions to self-monitor diet, exercise, and body weight. The standard intervention group used a study website for self-monitoring and the enhanced intervention group used additional technology, the BodyMedia Fit System® and a web-based platform, to receive real-time feedback on physical activity and energy expenditure for self-monitoring.

The enhanced group participants were instructed to wear the Minifly® armband while awake and use the device display and web interface to monitor their progress in achieving ≥ 60 minutes of moderate-intensity physical activity per day (≥ 5 days/week) and total daily energy expenditure. The online platform was developed by the manufacturer and allowed for self-monitoring of dietary intake. Participants were taught strategies to adjust their activity or intake throughout the day according to the real-time feedback.

At 6 months, there was no significant difference in percent weight loss between the two groups (estimated means, 9.4% for standard, 8.4% for enhanced, P = .15) but the standard group weight loss was significantly greater than the enhanced group at 12 months (8.9% vs. 7.0%, P=.01), 18 months (7.9% vs. 5.6%, P=.002), and 24 months

(6.4% vs. 3.6%, $P < .001$).[14] This data highlights the challenge of sustaining initial weight loss following intervention and suggests that using wearable sensors to monitor physical activity results in less weight loss than logging manually. The weight loss difference between the two groups in this study is clinically significant because research has established that greater weight loss results in improved health outcomes.[2] It is important to distinguish, however, that long-term weight loss for both groups in this study was substantially greater than the weight loss in the low-intensity CITY trial.[16]

The rationale for the weight loss difference between the two groups remains unclear, as no significant differences between the two groups were observed for physical activity and dietary intake behaviors. One hypothesis may be that the selected wearable device was difficult to use. Regardless, both groups had a significant decrease in sedentary time, increase in light-intensity physical activity, increase in 10 minute or longer bouts of moderate-to-vigorous physical activity, and decrease in total calorie intake across time. Participants in both groups had significant changes ($P < .01$) across time for many secondary outcomes such as fat mass, lean mass, percent body fat, bone mineral content, bone mineral density, and cardiorespiratory fitness with no significant difference between the two groups.[14] Thus, both interventions were successful in improving many factors related to behavior change and weight loss, but the rationale for the significant difference in observed weight loss is yet to be determined.

This long-term, randomized clinical trial provides high-quality evidence that the increasingly popular wearable sensors, currently marketed to monitor physical activity and daily energy expenditure, may not improve long-term weight loss outcomes. This

effect is likely amplified in the community among consumers who utilize these sensors without participating in an intensive weight loss intervention and who are also not guided to effectively integrate the device into their daily routine. Providers can apply the results from this study to clinical practice by cautioning interested patients about utilizing wearables for weight loss, while encouraging proactive behaviors and engagement in the process.

Recommendations for physical activity tracking in mHealth apps for weight loss that incorporate the above findings are as follows:

- Manually log minutes of moderate-to-vigorous physical activity in an app with the goal of achieving at least 150 minutes per week
- Use sensors to enhance user experience, not as a substitute to logging physical activity

METHODS

Study design

A lecture-based curriculum will be developed to educate PCPs about advising patients to use mobile applications as a tool for weight loss interventions. This lecture will be presented at professional medical conferences for CME credit.

Study population and sampling

This curriculum will be offered, in the form of a lecture, to providers at medical conferences for CME credit. Primary care providers and other personnel involved in patient weight loss will be invited to attend this 1 hour lecture to learn about current recommendations for patient use of mHealth apps for weight loss. This lecture can be presented at various conferences with the goal of increasing provider awareness of current research on weight loss interventions and mHealth app considerations such as efficacy, patient and app selection, features, recommended daily use, limitations, and gaps in literature.

Participants will be offered a pre -and post-test. It is predicted that post-score results will increase by 15% to a passing score of 80%. To generate a 15% increase in scores, a sample size of 28 participants is required. Presentation at 3 conferences with at least 10 attendees will meet the sample size criteria.

Recruitment

Primary care providers will be recruited by advertising this lecture in conference promotion material for registered attendees (mailers, e-mail, website). Offering this curriculum to various organizations will attempt to recruit providers from diverse locations and practices for wide dissemination of weight loss strategies. Participants will be incentivized to improve their weight-loss counseling and broaden their intervention strategies by earning 1 hour of CME credit for completing the curriculum.

Curriculum

The curriculum format will be a PowerPoint presentation. First, the epidemiology of overweight/obesity, principles of screening and treatment in the primary care setting, and efficacy of lifestyle interventions for weight loss will be discussed. Next, the presentation will describe patient use of mHealth apps for weight loss and discuss patient selection, choosing an app, common features, instructions for daily use, limitations, and future studies. Learning objectives for this curriculum are listed in table 5. A novel, evidence-based approach to patient use of mHealth apps for weight loss will be described as outlined in Table 6.

Table 5. Learning Objectives for mHealth App Use for Weight Loss

At the end of this lecture, the learner will be able to:
1. Evaluate every patient in the primary care setting to determine if there is an indication for weight loss
2. Assess patient readiness to make lifestyle changes for weight loss using the Stages of Change model
3. Summarize the benefits and limitations of high-intensity, in-person lifestyle intervention programs
4. Generate an individualized weight loss plan that addresses patient barriers and the 3 components of lifestyle intervention
5. Explain the role of mobile applications as a tool for select components of lifestyle intervention
6. Integrate patient use of mHealth apps into individualized weight loss plan using evidence-based strategies

Table 6. Daily mHealth App Logging Instructions for Weight Loss

Intervention component	Logging instruction	Frequency	Monitoring parameter
Diet	Record food & drink intake for dinner and at least 1 other meal	7 days/week	Daily caloric intake (kcal) relative to prescribed goal
Weight	Self-weigh and record	2-3 days/week	Weekly or monthly weight change relative to short and long-term goals
Physical activity	Record minutes of moderate-to-vigorous physical activity	7 days/week	Weekly minutes relative to prescribed weekly goal

Curriculum assessment

A pre-test will be delivered to assess provider baseline knowledge of indications for treatment with weight loss, the Stages of Change model, weight loss intervention options, the 3 components of lifestyle change, and current evidence for mHealth apps in weight loss. The learning objectives will be addressed after the pre-test and participants will be

provided with a hard copy of the learning objectives. The post-test will test the pre-test concepts again after the lecture to assess effectiveness of the curriculum and delivery. These tests will be administered using clickers that will be available for learner use during the lecture.

Study variables and measures

The pre- and post-tests will be the same 6 multiple-choice questions (12 questions total) presented in a case presentation format simulating patient-provider interactions. Each learning objective will be addressed in 1 question.

Data collection

The post-test will be administered at the end of the lecture. It is expected that all attendees will participate. Data will be collected using the Turning Point software and will be individualized to determine pre- and post-test scores for each participant. A score ≥ 80% will be considered passing.

Participants will also be encouraged to submit an electronic survey after the post-test that will collect demographic information (age, years in practice, specialty), use of current mHealth apps in practice, perceived utility of mHealth apps for weight loss, and attendee suggestions.

Data analysis

After data has been collected from ≥ 28 participants, a paired t-test will be applied to pre- and post-test results and the means will be compared. An item analysis will allow for investigation of learning objective mastery and question quality. These results will evaluate the effectiveness of this curriculum in teaching providers about weight loss in the primary care setting and evidence-based use of mHealth applications as a weight loss tool.

Timeline and resources

The lecture and presenter must be accredited through the ACCME organization to ensure quality and effectiveness of the curriculum, which may take up to 18 months. Upon receiving accreditation, conferences will be selected and offered the curriculum for presentation.

Institutional Review Board

The study protocol will be submitted for IRB exemption for educational studies to the Boston University Medical Campus IRB under 45 CFR 46.101 (b) criteria.

CONCLUSION

Discussion

The principles underlying successful weight loss are well established, but in order to counter the obesity epidemic, further studies are required to address dissemination, implementation, and maintenance of weight loss interventions.

Defining the role of mHealth applications in achieving sustainable weight loss requires further evaluation with large, high-quality, long-term clinical trials. Academic institutional partnerships with app developers may result in increased utilization of evidence-based strategies in commercial mHealth apps. Future research should inform best practices of mHealth app use such as ideal patient populations, app engagement characteristics and frequency, duration of use, provider engagement with patient data, and app limitations (e.g. accuracy of food databases).

The research cited in this literature review is limited by a number of factors, some of which have previously been stated. Many of these studies are limited by the narrow demographic composition of their study population, with a disproportionate number of study participants being young, female, white adults of high socioeconomic status. Additionally, some of the studies discussed in this paper are limited by selection bias. The recommendations included in this proposal are founded on the results of a select number of studies that have several limitations; as such, these recommendations should be interpreted as a preliminary evidence-based approach until more high-quality studies are available to inform practice.

The approach to weight loss in the primary care setting described in this article was designed for application by PCPs (physicians, physician assistants, nurse practitioners) among diverse patient populations in various settings. However, the generalizability of the expected weight loss outcomes cited in this review varies by the type of intervention; weight loss outcomes of high-intensity, on-site, comprehensive lifestyle intervention programs delivered by academic institutions and multidisciplinary teams are well-established and can be generalized to similar interventions. Alternative deliveries of weight loss interventions (primary care, online, over the phone, or commercial programs) have been shown to result in less weight loss, but the lack of high-quality data limits the generalizability of these findings. Interventions studying technology and mHealth apps for weight loss have mostly been implemented in select populations of patients, limiting the generalizability of these findings to the studied populations. However, the recommendations for mHealth app use described in this article were partially informed by a large sample size study that was not associated with any form of formal weight loss intervention. Thus, these recommendations for mHealth app use for weight loss may be applicable to the general population, but further study is warranted.

This approach to weight loss and integration of mHealth apps into lifestyle change planning is designed to enhance current clinical practice in the primary care setting with new, evidence-based recommendations for the use of widely available technology in the promotion of weight loss. These recommendations are generalizable to many apps but do not endorse specific weight loss apps. Thus, providers are encouraged to familiarize

themselves with mHealth apps and the relevant features before incorporating them into practice.

Summary

Overweight/obesity is a chronic disease affecting a majority of Americans[1] that results in significant morbidity and increased mortality.[2] The first line treatment for obesity is weight loss through comprehensive lifestyle intervention involving 3 central components: reduced caloric intake, increased physical activity, and behavior change. High-intensity, on-site programs result in clinically significant weight loss of 5-10% but demand a substantial amount of time and resources, limiting their potential dissemination and maintenance.[22]

Alternative modes of delivery, however, can apply the same evidence-based principles for weight loss in different settings. Technology has been studied as a tool to facilitate this process and enhance weight loss strategies such as self-monitoring and motivation.[11,12,24] Smartphones and mobile applications show promise for augmenting weight loss intervention programs,[16,17] but appear to be ineffective without provider involvement.[16,37] Providers have the opportunity to help patients integrate mHealth apps into their weight loss plans. Evidence-based recommendations will guide patients to confidently select an app and effectively use the features that facilitate behavior change for weight loss.

Primary care providers play a crucial role in patient health and have the ability to identify patients that can benefit from weight loss and support them throughout their

weight-loss journey. PCP involvement with weight loss planning and maintenance can assist patients with individualized problem solving, relapse prevention, and other cognitive and behavioral strategies.[33] PCPs are ideally situated to actively manage the variable barriers that patients face over time; the importance of this is highlighted by the fact that long-term provider contact results in increased weight loss over time.[2]

Novel recommendations for patient use of mHealth apps suggest encouraging the use of this technology for self-monitoring in patients who have a smartphone and are interested in using it to enhance weight loss efforts. The patient should select an app that he or she enjoys using and that has the capability of logging daily diet, weight, and physical activity. Meal and weight logging appear to have the strongest association with weight loss;[18,19] patients should be advised to log dinner and 1 other meal every day, log all minutes of moderate-to-vigorous physical activity, and log weight 2-3 times per week. Wearable sensors should not substitute for manually logging physical activity, but can be used to enhance user experience. Throughout the day, patients should monitor these parameters with regards to their goals and prescribed recommendations. Frequent provider contact will ensure close monitoring of weight-loss progress. The convenience of the smartphone logs will allow for brief assessment of daily logging patterns and identification of problematic areas. If short-term weight loss goals are not met, providers can inquire about individual challenges and assess the efficacy of the prescribed weight loss plan.

Clinical and/or public health significance

Educating providers about how to address overweight/obesity in the primary care setting and integrate the use of mHealth apps into prescribed weight-loss interventions has the potential to improve patient health and slow the rising prevalence of overweight/obesity in the United States. PCPs can implement these recommendations in clinical practice through a standardized approach to weight-loss with the goal of identifying and effectively treating overweight/obese patients prior to the development or progression of associated complications.

With an individualized approach, providers can address patient-specific barriers and create a plan for weight loss that incorporates evidence-based principles for a reduced calorie diet, increased physical activity, and behavior modification. PCPs can enhance patient involvement by recommending use of mHealth apps as a tool for self-monitoring diet, weight, and physical activity. Provider guidance of appropriate app use and integration of apps with prescribed lifestyle changes may increase adherence to weight loss plans by simplifying the process of self-monitoring and encouraging active engagement in the intervention. Supportive mHealth app features such as daily goal reminders, exercise challenges, and user discussion forums may help to enhance patient participation and immersion in their weight-loss journey. With mHealth apps promoting successful behavior adaptation, patients will hopefully gain a sense of accomplishment, self-achievement, and an internal motivation to pursue sustainable weight loss.

LIST OF JOURNAL ABBREVIATIONS

Ann Intern Med	Annals of Internal Medicine
Am J Med	The American Journal of Medicine
Am J Prev Med	American Journal of Preventive Medicine
Ann Behav Med	Annals of Behavioral Medicine
Ann Rev Nutr	Annual Review of Nutrition
BMJ Open Diabetes Res Care	British Medical Journal Open Diabetes Research and Care
J Am Diet Assoc	Journal of the American Dietetic Association
JAMA	Journal of the American Medical Association
JAMA Intern Med	Journal of the American Medical Association Internal Medicine
J Fam Pract	Journal of Family Practice
J Gen Intern Med	Journal of General Internal Medicine
J Med Internet Res	Journal of Medical Internet Research
Mayo Clin Proc	Mayo Clinic Proceedings
Med Clin North Am	Medical Clinics of North America
N Engl J Med	New England Journal of Medicine
Prev Chronic Dis	Preventing Chronic Disease
Prog Cardiovasc Dis	Progress in Cardiovascular Disease
Sci Rep	Scientific Reports

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